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PORTABLE CHANNEL TEST FACILITIES

This note describes the development under way at SRI of portable experimental facilities for conducting measurements of packet radio channels. The portable equipment is intended to supplement the facilities also under construction at SRI which include RF propagation and noise measurement instruments organized around minicomputers and housed in a mobile van. This note concentrates on the portable equipment and its impact on the experimental capacity of the facility.

Purpose of Test Facility

There are several reasons for the development of a Packet Radio Channel Test Facility. The first objective is to study the propagation and noise characteristics of the channel and the minicomputer based equipment is intended to satisfy this objective.

Subsequent objectives include:

- Validation of the analytical models
- Verification of simulation results
- Providing a simulation vehicle for testing design concepts

For example, the facility should be useful in validating the propagation, noise, and channel access models upon which the system design is based. As an example of greater detail, the facility must serve as a tool in verifying network simulation results comparing different acknowledgement procedures. It must also allow us to exercise and test network components--such as the repeater under development at Collins Radio Corporation. Perhaps one of the most important functions of the test facility should be to provide hands-on experience with differing design concepts and to help identify problems which are not easily anticipated or subject to analysis. An excellent example of such a problem is operating a widely dispersed radio net using wideband signals in an actual RFI environment.

Experiments

To satisfy these and other objectives the facility must be capable of supporting a wide variety of experiments:

- Bit error rate and Packet error rate experiments to validate design selection of parameters such as power, antenna, frequency, bit rate, and packet length.

- Channel loading experiments to validate access scheme models, acknowledgement scheme models, test capture effect, and test design concepts under traffic stress.

- Interference experiments to determine the effect of an RFI environment on the network, and the effect of the network on existing RF systems.

- Detectability experiments to determine the ease of detection of terminal/repeater/station presence by an interceptor.

Although all of these experiments cannot be conducted during the balance of the fiscal year, the design and development of the test facility must result in instrumentation capable of supporting later more advanced experiments with inexpensive modifications.

Desirable Features

To support the experiments planned for the present year, several traffic sources are required. These sources must generate suitable bit patterns and transmit them via modems and RF transceivers.

It is essential that such traffic sources be flexible nnd mobile. Flexibility is necessary so that assorted packet lengths and variable channel access schemes may be simulated by the sources, and so that ACK and routing schemes selected for study may be tested with multiple sources in varying geometries. Mobility is necessary to vary the geometry easily and to enable us to test the effects of moving sources.

The dual requirements of flexibility and mobility are difficult to satisfy, because flexibility suggests the use of minicomputers to generate bit patterns and to control the access / acknowledgement logic in the simulators and minicomputers are not particularly mobile. This is a non-trivial problem because the lack of portability limits our experiments to mobility of only one packet simulator, a maximum of two simultaneous traffic sources, and a limit of one repeater transmission hop.

Originally, an alternative use of microprocessors for flexible and portable control was thought impractical because of the slow speed of available microprocessors. However, a re-examination of the problem has convinced us that we can use recently announced microprocessors which offer adequate speeds.

We are presently constructing an experimental facility composed of two minicomputers and additional portable equipment organized around microcomputers. We plan to use a single SRI-owned minicomputer to control two fixed-site packet simulators, an additional minicomputer in the mobile van, and several portable simulators. With this equipment we should have an adequate combination of flexibility and mobility.

Portable Instrumentation Plan

The first portable simulator, under construction, will be capable of functioning as both an unattended traffic source and as a general purpose experimental device. It will be light weight, compact, battery powered (along with AC), and simple to use. In order to facilitate later experiments and to provide checkout, calibration, and experimental variations, the unit will be constructed with integral keyboard and display.

Our plan is to eventually develop two general purpose simulators housed in a case approximately the size of a TI silent 700 terminal (slightly bigger than a standard 5 1/2-inch attache case) and one or more limited purpose hand-held devices which would resemble large walkie-talkies (if time and scope of the effort permit).

This plan is based on the observation that the packaging engineering expense and time will be prohibitive if we attempt to house our general purpose devices in hand-held units. Thus, the larger units are viewed as general purpose flexible instruments to be fabricated at reasonable packaging expense. To eliminate a considerable engineering problem, the hand-held unit (if any) will be designed for a limited application, i.e., special purpose.

For the purposes of this discussion, we shall refer to the larger units as suitcase simulators (SS) and the smaller units as hand-held simulators (HHS).

Suitcase Simulators (SS)

The SS will operate on three alternative power supplies, (1) 110 VAC, (2) rechargeable batteries, and (3) non-rechargeable batteries.

A general illustration of the planned SS is displayed in Figure 1. The principal components included in the simulator are: (1) keyboard, (2) display, (3) printer, (4) microcomputer, (5) interface, and (6) RF/modem. Each of these components are essential to a well balanced experimental program. The rationale behind the selection of each component are discussed below:

The RF and modem are obviously essential to generate and receive suitably modulated RF signals. The interface is necessary for linking the microcomputer to the modem and for performing certain digital functions at the data rate which may not be feasible in the microcomputer. The error detection function will certainly be resident in the interface. It is not clear, at this time, whether the address function should also reside in the interface. The microcomputer and memory are important for experimental control and are necessary for varying various parameters (e.g. access mode, ACK schemes, packet formats, etc.) and for simulating multiple traffic sources. The keyboard is for initiating and changing experiments, introducing source data for a variable traffic source and, possibly, for providing communications during the experiments. The display will enable us to check out our data, support the keyboard and

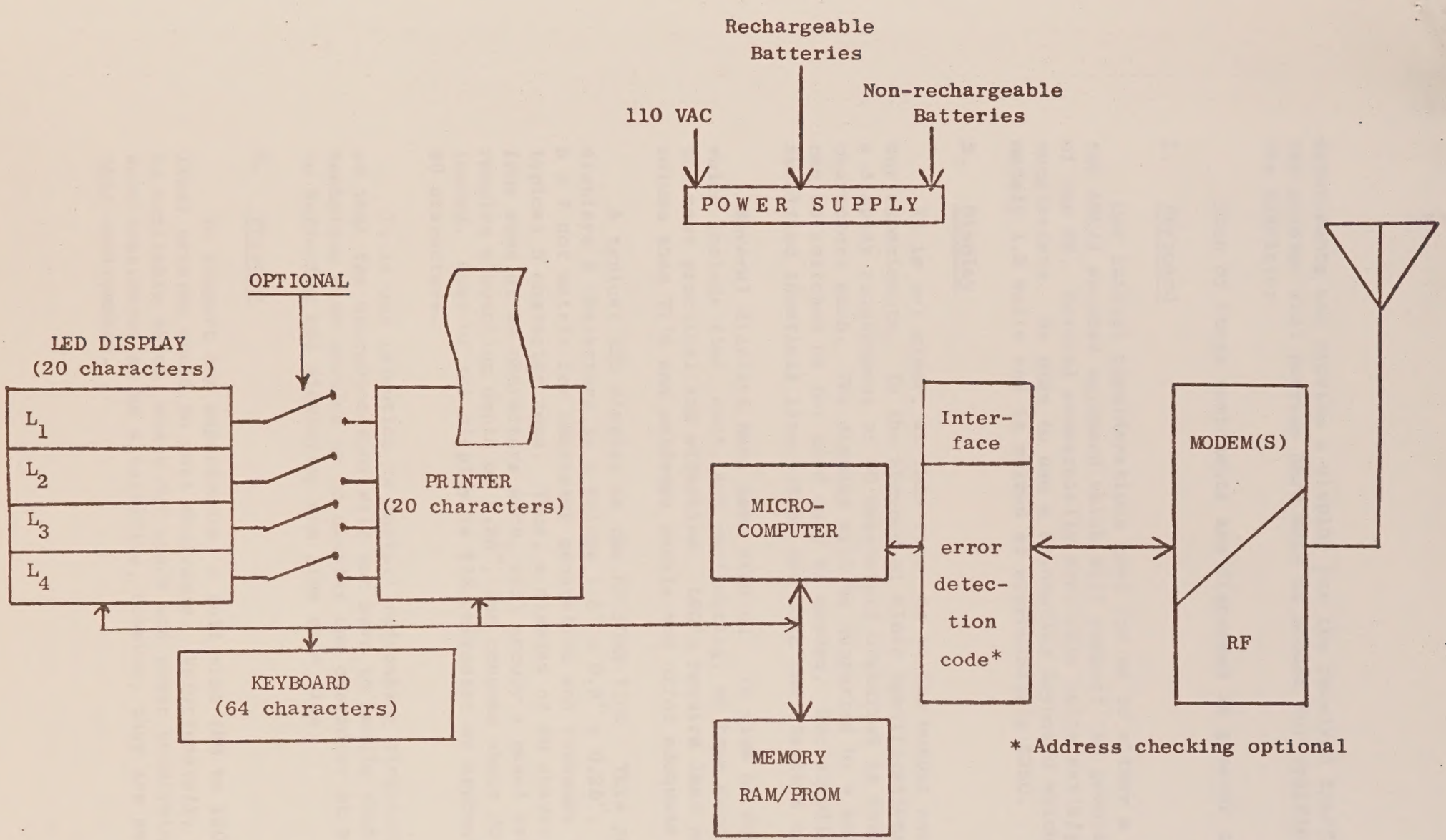

Figure 1 - FUNCTIONAL ILLUSTRATION OF SS

experiments and provide a display for the received traffic. Finally, the printer will provide hard copy as needed for traffic received at the simulator.

Each of these components are discussed in greater detail below.

1. Keyboard

Our initial considerations have led us to either a 64 or 72 character ASCII encoded keyboard which will support the general purpose function of the SS. Several commercially available units satisfy our size-power constraints. We plan to use a Datanetics keyboard which consumes approximately 1.2 watts and is priced at approximately $250.

2. Display

It is not clear, at this time, as to the output necessary to support our experiments. In the absence of clear specifications we are assuming a display requirement of 80 characters organized in four lines of twenty characters each. The display will be supported by a small printer which can be switched on for hard copy as needed. For simplicity we have specified identical line widths for both the displays and printer.

Several displays have been studied. In view of our requirements which include time, cost, and engineering, we have concluded LED's are the most practical and effective. LED's require less power and packaging volume than TV's and selfscan panels and offer adequate resolution.

A typical LED display is the HP 5082-7102. This particular module displays 5 characters in a volume 1.6" x 0.6" x 0.25". The LED uses a 5 x 7 dot matrix for character generation and consumes 1.25 watts for a typical 5 character load. Thus, a display of 80 characters organized in four rows of 20 characters each, will occupy a panel area 6.4" x 2.4", require a mounting depth of 0.25", and consume about 20 watts fully loaded. Cost of the display is $18/character or approximately $1500 for 80 characters.

It is our intention to install refreshing circuitry with the LED's so that the microprocessor will not have to handle that burden. This technique also enables us to display one character at a time as opposed to buffering and displaying one line at a time.

3. Printer

To support our experiments, a full size (80 to 120 characters per line) printer would be most desirable. Unfortunately, no such printer is available which meets our space and power constraints. Strip printers were considered as an alternative, however, they are awkward to use in this environment.

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A representative printer for this application is the Amperex Model 60 SA. This is a 5 x 7 dot matrix printer with a maximum print rate of 50 characters/second and a line width of 20 characters--compatible with the planned display. The unit under consideration is a ribbonless printer which uses 2.5" paper rolls. The model 60 SA is available from stock for approximately $210. Associated electronics and character generators cost an additional $200.

This printer draws about 40 watts when printing. However, standby power is zero when the unit is idle. Of course, this power drain cannot be sustained for indefinite periods and the intent is to use the printer only when hard copy is desired, or, when operating off a 110 VAC power source. The size of the printer is 6" x 8" x 4" and it weighs about 5 pounds.

4. Microcomputer

The microcomputer will function as the equivalent of an ALOHA BCU and will enable us to experiment with various access schemes, buffering, and packet structure without the burden of excessive changes in the electronics. The I/O data rates will be controlled by an external clock.

Several microprocessors and memories have been examined, ranging from 4-bit to 16-bit processors and varying considerably in speed. We were particularly interested in the Intel 8080 8-bit chip, however, this unit isn't available until the end of the first quarter 1974.

If the microprocessor were organized around an Intel 8008 8-bit CPU chip, it might include a 2-phase clock, TTL interface to memory, 1000 8-bit bytes of RAM, 1000 bytes ROM/PROM, and 2 input and 4 output ports. Total power consumption would be approximately 17 watts.

National Semiconductor offers a processor similar to the Intel 8008 chip, except it operates in 4 tandem 4-bit slices, equivalent to a 16-bit processor. As a microprocessor the IMP 16 costs $1000 and consumes about 19 watts.

The 1101 RAM chip from National is typical of microprocessor memories. The 1101 is a 256 bit fully decoded unit with an 850 nsec access time. For modulating the RF with a 1000 bit packet, a shift register memory such as the Intel 1402 would allow operation up to 5 megabits per second. At a 1 MBS rate, this unit would consume 0.1 mW per bit (100 mW for 1024 bits). At the proposed 100 KBS rate, the power consumption would be about 20 mW. A similar unit, manufactured by Hughes (HDSR 1024 operates up to 10 MBS at 300 mW dissipation.

For longer term storage, slower shift registers which consume less power are available. For example, Microsystems International offers an 8K shift register which consumes 2 mW in the idle mode. It can be operated up to 200 KBS in the "LOAD" or "DUMP" mode. Low standby power allows the unit to be continually refreshed from its own batteries without excessive drain so that, for example, a 40K bit memory would only consume 1 watt in 10 hours.

During the second week of October, we met with several other Packet Radio Working Group personnel to attempt to select a microprocessor for the first iteration in constructing a repeater and SS. This group included Dave Brandin and Stan Fralick, SRI; R. Van Slyke, NAC; Chris Harrison, University of Hawaii; and D. Walls, Collins Radio. Salesmen from Intel and National made presentations and we also visited a National office. We were especially concerned with our interface requirements and the external communications offered by the different manufacturers.

At this meeting we concluded that National's IMP 16C would meet our timing and processing requirements with the addition of a Direct Memory Access (DMA). It is, however, a difficult machine to prototype. Fortunately, National also markets a prototyping version of the IMP 16C, model 16L, which includes a prototyping console, DMA, RAM and PROM memory, and a TTY interface and other features.

Accordingly, the group elected to purchase IMP 16L's for prototyping and development and agreed to use the base 16C chips in constructing our components. It should be noted that this decision does not limit our options in the future and we agreed that the entire question of microprocessors would be re-opened later in the projects.

The IMP 16L is a 16-bit processor with 60 general purpose (macro) instructions defined in two Control ROM's (CROMs). It has 4 multi-purpose registers, memory (RAM-PROM-ROM) addressable to 65,536 words, and a 1 MHz DMA. It can perform a register-to-register addition in 4.9 μsec.

Initially, we intend to develop code in RAM memory. We will move code to PROM's as appropriate later in the development. We shall use an Intel programmer to develop our PROM's by utilizing pin-to-pin adapters and performing some level changes in the programmer.

5. RF-Interface Modem

The plan is to instrument the SS with an RF package and appropriate interfaces so that measurements may be conducted. The long range plan is to install Collins supplied RF gear. However, during the interim period we may elect to install commercial RF gear.

The Sankyo radio, presently being installed in the ALOHA TCU's and repeaters is quite compact and would satisfy our space and power requirements. Utilizing this equipment would enable us to commence packet experiments as early as possible and, in addition, the units would be ALOHA compatible. To accommodate both the ALOHA protocol and the Collins based modulation and experiments we anticipate providing the controls via microcomputer software.

SRI is fabricating the necessary interface circuitry and will include error detection logic in the interface. At this time, we have not yet decided whether we will install the address checking logic in the interface.

Power

The planned SS has three alternative power supplies: (1) 110 VAC, (2) primary non-rechargeable batteries, and (3) rechargeable batteries. Table 1 lists the planned components and their general power requirements (worst case).

Table 1. SS GENERAL POWER REQUIREMENTS

Component	Power	Comments
Keyboard	1 w	
Printer	40 w	zero in idle mode
LED's (80 char.)	20 w	full load
RF - xmit	10 w	zero in receive mode
RF - receive	2 w	
Microcomputer	20 w	
Miscellaneous	5 w	
	98 watts	

If rechargeable batteries are used, we anticipate about 25 watt-hours per pound. Non-rechargeable batteries, e.g., lithium, offer 100 watt-hours per pound. Thus, a battery pack of two pounds should power the SS for one to four hours depending on the load. Of course, an A/C power supply eliminates any power problems, but does reduce the portability to some extent.

Hand Held Simulators (HHS)

We plan to fabricate a second SS after the first is validated. Upon completion of the second SS--which will reflect expertise gained in building and using the first SS--we plan to fabricate a hand-held unit (HHS) for use in the experiments. The HHS will be battery powered and will consist of five major components: (1) small limited keyboard, (2) battery pack, (3) microcomputer, (4) RF-modem-interface, and (5) small display.

The HHS is intended for very limited applications in the measurements. The keyboard will be used for commanding a set of fixed traffic patterns and messages. The microcomputer will function as the traffic generator while the display will serve a limited output/receive function. Some general purpose functions will be accommodated so that some original traffic can be initiated/received at the HHS. The unit is displayed in Figure 2.

Besides introducing some new engineering / packaging problems, the development of the HHS will enable us to investigate applications and usage of a packet radio system and their impact on design.

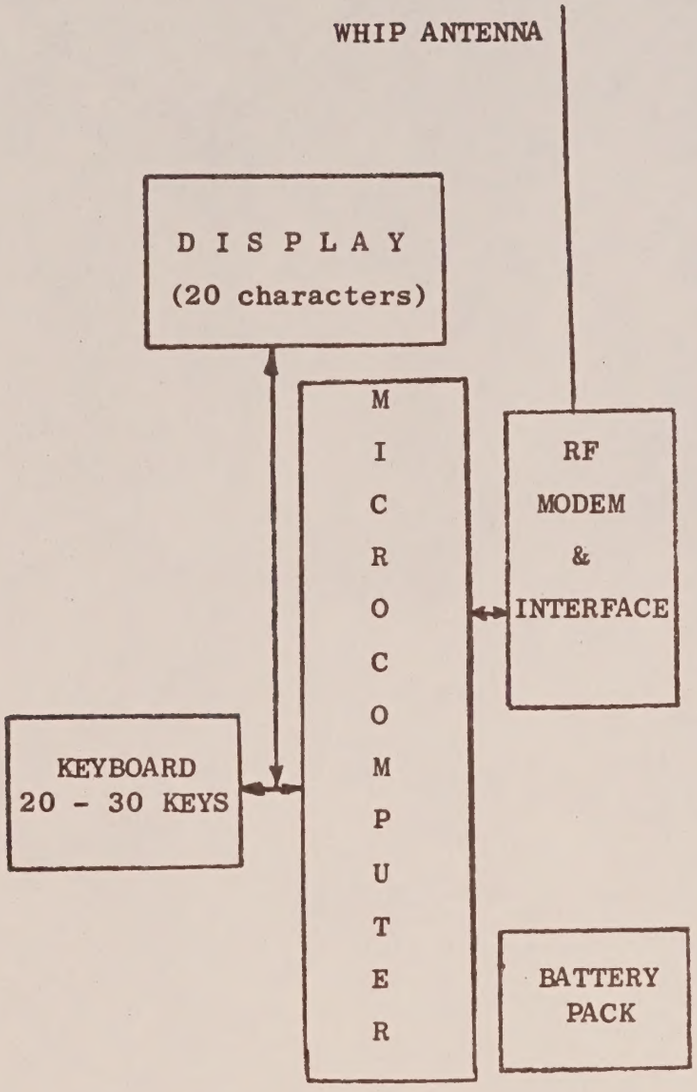

Figure - 2 FUNCTIONAL ILLUSTRATION OF HHS